Analysis of path and genetic dicision of plant-type traits in compact rapeseed (*Brassica napus* L.) lines

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Abstract

In this study, 30 crosses were made by Griffing methodIusing 6 rapeseed (*Brassica napus* L.) lines which have different genetic background and plant-type traits. The effects of plant-type and yield characters on yield per plant were estimated by using path analysis and decision analysis. The results were as follows. (1) Number of siliquae per plant was the most important trait to yield per plant in direct and total effects. Important traits to yield per plant in direct effect were 1000-seed weight and seeds per silique, but their great negative effects on other traits resulted in minor total effect to yield per plant. The direct effect of all studied plant-type traits to yield per plant was minimal, however some of them such as siliques and length of main inflorescence, length of primary branches, siliques of effective primary branches had large indirect effects; (2) For yield per plant the principal decisive traits were siliques per plant and siliques of effective primary branches, and the secondary decisive traits were effective primary branches and length of main inflorescence. The principal restricted traits were 1000-seed weight, effective branching height.

Key words: Compact rapeseed line, Plant-type traits, Yield traits, Decision analysis, Path analysis

Introduction

The performance of yield per plant is affected by all traits in rapeseed. These traits are composed of plant-type traits and yield traits, and their effects on yield per plant are not equal, some of them are direct, or indirect, and the relations between them and yield per plant are positive or negative, therefore, all these factors will result in greater difficulties of decision for breeders who improve the yield by selecting other traits connected with yield per plant. The effects of Xi to Y can be revealed direct and indirect effects using Path analysis[1], but to reveal the relationships between a few of×variant and y sometimes is difficult to judge which variable is the principal decisive or restricted variable. The total effects of every independent variables to response variable can be counted by decision coefficient ($R(i)^2 = 2 \times bi \times r_{iy} - b^2 i$) theorized by Yuan Zhi-fa[2], and ranking them according to their effects, the variable with maximal value is the principal decisive variable, on the contrary the smallest variable, if its decisive coefficient is negative, it is certainly the principal restricted variable. The chief decisive and restricted traits of aimed traits can be obtained by analysis and comparison of genetics relation coefficient and decisive coefficient. In this paper, not only the direct and indirect effects, but also genetic decisive coefficient of plant-type traits and yield traits to yield per plant were mainly studied in order to obtain the principal decisive and restricted traits for improving yield per plant and provide theory for breeding hybrid rapeseed.

1 Materials and Methods

1.1Materials and Designs

Five compact (P_1-P_4, P_6)and one loose rapeseed strains (in *Brassica napus*.L) were employed in the test, their genetic background was as follows. P_1:1721-1B/Ganbai No. one ; P_2:7399-8/A74 ; P_3:8906A/Rub/Z57//Danza 875; P_4:083/Altex//shaan2B; P_5:yellow Ken C1 ; P_6:1721-1B/Start//955B. 30 combinations were gotten by Griffing methodIin 2001, and all of them and their parents were planted in the field of Hybrid Rapeseed Research Center of Shaanxi Province in 2002, according to randomized complete block design, each plot replicated three times with three rows, each row was 2.6 m, the row spacing and plant spacing was 0.4m×0.166m, which was equal to 150000 plants/hm^2.

1.2 Experimental Methods

Within the 3th-5th day, after rapeseed flower ending in 2003, 10 plants with the same growth vigour were selected in the middle row of each plot, then labeled them and measured the angles between stem and branches from the first to fifth from top to foot, and their average value was used as the angle between stem and branches of individual plant for statistical analysis. In the 5^{th} days before maturity, the ten rapeseed plants labeled were removed from each plot to measure the following traits: plant height, effective branch height, length of main inflorescence, effective primary branches, relative length of branch part(the different value between last branch height and effective branch height), silique length, silique width, length of primary effective branch, relative length of primary effective branch (the proportion of the length of the part having siliques in primary branch to that of primary branch), siliques of primary effective branches, siliques of main inflorescence, siliques per plant, seeds per silique. After maturity, yield per plant was gotten according to the yield and No. of the plants of each plot, 1000-seed weight was gotten, too.

1.3 Statistical analysis

The genetic decisive coefficient of all traits to yield per plant was counted using $R^2(i) = 2 \times b_i \times r_{iy} - b^2_i$ (YUAN Zhi-fa etc.2001)[2]. In the above formula, b_i denotes direct path coefficient of some trait to goal trait, r_{iy} is the relation coefficient between some trait and the goal trait, if $R(i)^2>0$, the corresponding trait is decisive trait, if $R(i)^2 \leqslant 0$, that is restricted trait, the trait which of $R^2(i)$ is close to zero is basically kept.

2 Results and analysis

2.1 Path analysis of plant-type traits and yield traits for yield per plant

Table 1 The direct and indirect effects of plant-type traits and yield traits for yield per plant

Characters	Direct effect	Indirect effect	Total effect	Characters	Direct effect	Indirect effect	Total effect
Plant height	0.006	0.340	0.346	Silique density	0.210	-0.035	0.175
Effective branch height	0.195	-0.554	-0.359	Seeds per silique	0.591	-0.377	0.214
Length of main inflorescece	0.043	0.610	0.653	1000-seed weight	0.812	-0.819	-0.007
The last branch height	-0.208	0.061	-0.147	Silique length	-0.095	-0.088	-0.183
Relative length of branch part	-0.029	0.134	0.105	Silique width	0.052	0.373	0.425
Effective primary branches	0.298	-0.051	0.247	Relative length of effective primary branch	-0.086	0.263	0.177
Siliques of effective primary branches	0.132	0.470	0.602	Length of effective primary branch	-0.023	0.610	0.587
Siliques of main inflorescence	-0.078	0.700	0.622	Angle between Stem and primary branch	-0.028	-0.148	-0.176
Siliques per plant	0.864	-0.193	0.671				

Note: Relative length of branch part equals to the ratio between the length from 1st to the last branch and plant height. Relative length of effective primary branch equal to the ratio between the distance from the 1st to the last silique on primary branch. Length of effective primary branch is the distance from the 1st to the last silique on primary branch.

The trait which has the maximal direct effect on yield per plant among the 17 traits in table 1 was siliques per plant, secondly 1000-seed weight and seeds per silique. It showed that the three traits have always larger direct effect on yield per plant. However, siliques per plant has smaller negative indirect effect, while 1000-seed weight and seeds per silique have more larger negative indirect effects on yield per plant through other traits. Therefore the total effect of siliques per plant to yield per plant was bigger (0.671), while the total effect of 1000-seed weight and seeds per silique were smaller (-0.007 and 0.214). All plant-type traits had no bigger direct effects, but some of them have bigger indirect effects, for example, the direct effect of effective branch height, length of main inflorescence, plant height, silique width, length of effective primary branch were 0.195, 0.043, 0.006, 0.052 and -0.023 respectively, while their indirect effect were -0.554, 0.610, 0.340, 0.373 and 0.610 respectively. As a result, the total effects of these plant-type traits to yield per plant were bigger.

Other traits had smaller direct and indirect effects on yield per plant, so their total effect on yield per plant were also smaller, such as the last branch height (-0.147), angle between stem and primary branch(-0.176), silique length(-0.183), relative length of branch part(0.105), silique density(0.175), relative length of effective primary branch(0.177) and effective primary branches (0.247).

2.2 The genetic decisive analysis of plant-type traits

Ten traits that their decisive coefficients were all positive in table 2 were in turn siliques per plant (0.413), siliques of effective primary branches(0.1415), effective primary branches(0.0584), length of main inflorescence(0.0543), silique width(0.0415), silique density(0.0294), silique length(0.0257), the last branch height(0.0179), angle between stem and primary branch(0.0091) and plant height(0.0041).From these decisive coefficients, it showed that siliques per plant was the principal yield trait, it should be improved as the major trait in breeding practice, and then siliques of effective primary branches. Moreover, a comprehensive consideration about effective primary branches, length of main inflorescence, silique width, silique density and silique length were given on the base of the special performance of parents in breeding practice.

These traits which their decisive coefficients were negative were 1000-seed weight (-0.6707), effective branch height (-0.1780), siliques of main inflorescence(-0.1031), seeds per silique(-0.0963), relative length of effective primary branch(-0.0378), length of primary branch (-0.0275) and relative length of branch part in stem (-0.0063). It suggested that 1000-seed weight and effective branch height were the chief restricted traits of yield per plant because of their larger negative indirect effects, although they had larger direct effects to yield per plant. Therefore, 1000-seed weight and effective branch height should be properly lowered in breeding. Siliques of main inflorescence and seeds per silique were less important restricted traits because of their smaller direct effect or larger indirect effect. For instance, the direct effect of seeds per silique was positive (0.5910), while its larger negative indirect effect through other traits resulted in negative genetic decisive coefficient (-0.0963) to yield per plant, so do not harshly improve it.

In addition, because branch-end height, angle between stem and primary branch, plant height and relative length of branch part in stem had not significant effect to improve yield per plant and their genetic decisive coefficients were close to zero, so they only need maintaining in breeding.

Table2 The genetic decision coefficient of plant-type traits and yield traits for yield per plant

Characters	$R_{(i)}^2$	Order	Characters	$R_{(i)}^2$	Order
Plant height	0.0041	10	Silique density	0.0294	6
Effective branch height	-0.1780	16	Seeds per silique	-0.0963	14
Length of main inflorescence	0.0543	4	1000-seed weight	-0.6707	17
The last branch height	0.0179	8	Silique length	0.0257	7
Relative length of branch part	-0.0069	11	Silique width	0.0415	5
Effective primary branches	0.0584	3	Relative length of effective primary branch	-0.0378	13
Siliques of effective primary branches	0.1415	2	Length of effective primary branch	-0.0275	12
Siliques of main inflorescence	-0.1031	15	Angle between Stem and Primary branch	0.0091	9
Siliques per plant	0.4130	1			

3 Discussion

Decisive coefficient is different from correlation coefficient which mainly analyzes concomitant variation between traits. The correlation between non-goal traits which always lead to more difficulties was not considered when we use correlation to improve the goal trait through indirect selection. Decisive coefficient is also different from determinant coefficient that can reflect the determinant effect of a few of independent variances to dependent variances, but the correlative information(indirect effect) and direct effects between traits relating to some non-goal traits can be synthesized into complex index (decisive coefficient) using analysis of decisive coefficient. Then the decisive, restricted traits and keeping traits of the goal traits will be obtained to be utilized conveniently in breeding practice according to the order of the decisive coefficient, especially for these traits which of the correlation coefficients are very close, or significant but are not distinctly different from zero.

Yield is a comprehensive performance of all plant-type traits and yield traits. There were distinct differences in the effects of all traits to yield per plant in the study. Some of them had smaller direct effects, but larger indirect effect to yield per plant. However, some traits had larger direct effects and negative indirect effect through other traits to yield per plant, thus leading to smaller total effects to yield per plant. For instance, among of the three traits of yield, siliques per plant, seeds per silique and 1000-seed weight have larger direct effects, but the two formers have larger negative effects, thus resulting in smaller total effects to yield per plant, namely 0.214 and -0.007, while the latter has smaller negative effects. Moreover, the direct effect of effective primary branches to yield per plant was also larger. However, some other plant-type traits studied in the test showed they had larger total effects to yield per plant because of larger indirect effects to yield per plant, although they have no significant direct effects. For instance, the direct effect of effective branch height and length of main inflorescence to yield per plant were 0.195 and 0.043, then their indirect effects were -0.554 and 0.610, total effects were -0.395 and 0.653. Besides, the total effects of siliques of effective primary branches, silique width and siliques of main inflorescence and length of effective primary branch were 0.620, 0.425, 0.622, 0.587, respectively, they all had larger total effects to yield per plant.

Above analysis suggested that siliques per plant and siliques of effective primary branches were the principal decisive traits and should be continually improved, which was the same as Shen Jin-xiong's[3], and we should pay attention to effective primary branches and length of main inflorescence too. In addition, 1000-seed weight and effective branch height were principal restricted traits and should be lowered properly. All these traits which greatly affect yield should be firstly considered in improving varieties using heterosis. While branch-end height, angle between stem and primary branch, plant height and relative length of branch part in stem need to be kept

References

1 Akdag C S, Ehirali S. A study on the relationships among characters and path coefficient analysis in chickpea (Cicer arietinum L1) 1 Tr J Agric Forest, 1992, 16:763-772.

2 Yuan Zhi-fa, Zhou Jing-yu, Guo Man-cai, Lei Xen-qin, Xie xiao-li. Decision coefficient--the decision index of path analysis. Jour. of North west Sci-Tech Univ. of Agri. and For. (Nat. Sci. Ed.). 2001, 29(5):131-133.

3 Shen Jin-xiong, FU Ting-dong, YANG Guang-sheng, MA Chao-zhi,TU Jin-xing. Analysis of heterosis reveals genetic improvement for yield traits in rapeseed(*Brassica* napus L.). Chinese Journal of Oil Crop Sciences. 2005, 27(1):5-9.